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Washington, DC 20006

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FEDERAL COMMUNICATIONS COMMISSION
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Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
The Portals
445 12th Street, S.W.
Washington, D.C. 20554

<u>CC Docket No. 96-98</u>

Dear Ms. Salas:

Attached please find two white papers for submission by MCI WorldCom in the above-referenced docket. The paper titled "Unbundling Digital Loops Carriers" describes digital loop carrier technology and explains how loops provided using integrated digital loop carriers may be unbundled in digital form and made available to CLECs. The paper titled "ADSL with Digital Loop Carriers" describes how ADSL may be provided on lines served by DLC and several options for CLEC interconnection.

In accordance with section 1.1206(b)(2) of the Commission's rules, 47 C.F.R. § 1.1206(b)(2), an original and one copy of this letter and attachments are being filed with your office.

Sincerely,

Lori Wright

Lori Wright
Senior Manager, Regulatory Affairs

cc: Jake Jennings
Chris Libertelli

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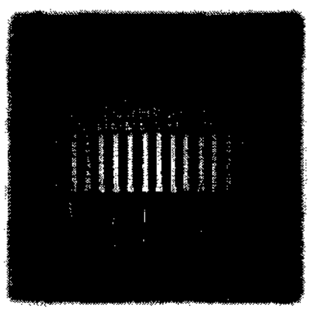
List ABCDE

MCI WORLDCOM
Law and Public Policy

ADSL with Digital Loop Carriers



May 1999

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INTRODUCTION

Unbundling network elements is key to local competition. The simplest way to unbundle a local loop is to provision an all copper loop. However, in order to satisfy future loop design standards, a growing number of loops are being provided over Digital Loop Carriers (DLCs) and appear in digital format as they enter the central office. MCI WorldCom's earlier paper, *Unbundling Digital Loop Carriers*,[1] discussed the complexities of unbundling voice grade loops served by digital loop carriers. This paper describes how ILECs can provide Asynchronous Digital Subscriber Line (ADSL) with digital loop carriers (DLCs) and then discusses ways CLECs can interconnect to an ILEC network containing DLCs to provide ADSL to their own customers.

The phenomenal popularity of the Internet has created substantial demand for high-speed local access to relieve the "World Wide Wait" caused by the local loop and switching bottlenecks. Standard loops and circuit switching are limited to about 56Kbps with ISDN-BRI delivering up to 128 Kbps. ADSL can meet the high-speed access demand without deployment of new loop plant. ADSL is an advanced modem technology using high frequencies to transmit voice *and* high bit rate data (up to 8 Mbps to the customer and 1 Mbps to the central office) over a single copper loop. Unlike lower speed modems that can be connected on very long loops, ADSL modems must be connected at the ends of a copper loop only up to a certain distance, i.e., usually 18,000 feet.

Studies show that the average voice call lasts approximately 3.5 minutes while the average Internet call lasts 30 minutes. This imbalance along with the increasing popularity of the Internet and telecommuting strains the existing circuit switched network. ADSL greatly benefits the service provider by separating the data traffic from the voice signal that enters the switch, thereby delaying or eliminating expensive voice switch upgrades or replacements.

ADSL OVER HOME RUN COPPER

ADSL is typically provided over a copper pair that goes straight from the customer premises to the central office (home run copper) and must meet certain restrictions. The pair cannot be over 18,000[2] feet, have load coils, or have excessive bridge tap lengths.[3] Load coils are used on longer copper loops (usually over 18,000 feet) to enhance the voice signal, but the electrical properties of load coils block high frequencies, preventing the loop from supporting ADSL. Bridge taps are unterminated connections off a main loop that add additional resistance to the loop. They have little effect on voice but can

[1] The paper can be downloaded from http://www.bullcreek.austin.tx.us/mci_worldcom.html.

[2] This is a function of a vendor's hardware and software. A few vendors have announced products that can support reaches of up to 24,000 feet.

[3] A properly designed network that conforms to the Carrier Serving Area (CSA) should not have any ADSL loop requirement problems since it is already designed to support ISDN.

disturb high frequency transmission by increasing impedance and insertion loss on the loop and reflecting the high frequency signals.

In addition to high-speed digital transmission, ADSL also permits simultaneous voice band transmission over the same copper pair (see Figure 1).

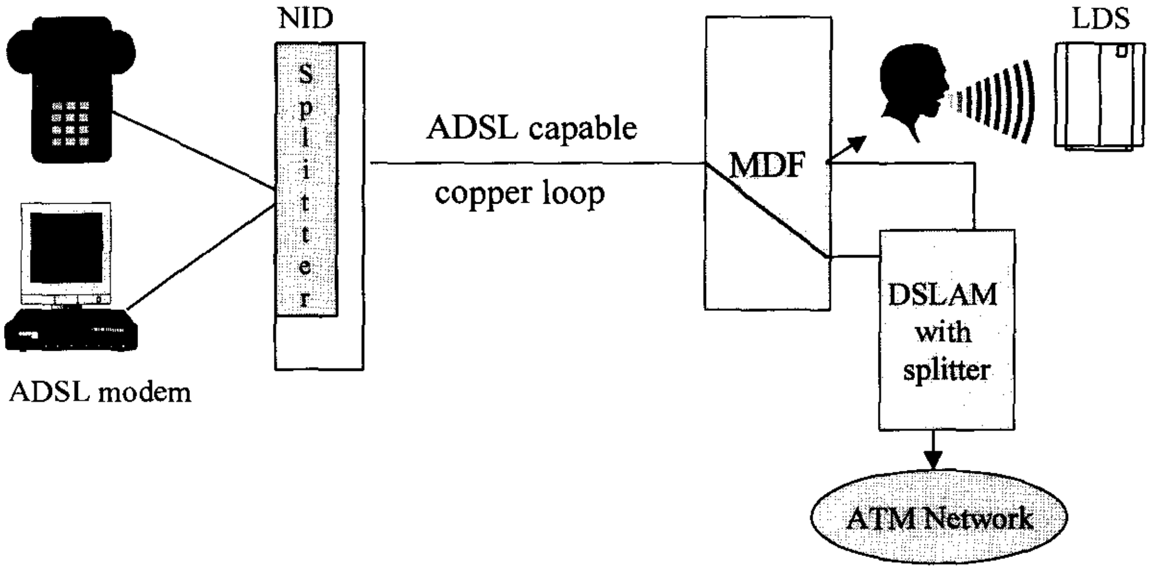


Figure 1 ADSL over home run copper

The voice channel and the high-speed data channel occupy different frequency spectrum and are combined or separated at either end of the loop but are carried together between the central office and the customer premises. As shown in Figure 1, the traffic is split out at the Digital Subscriber Access Line Multiplexer (DSLAM) in the central office with the voice going to the Local Digital Switch (LDS) and the data going to a data network such as ATM.

The achievable data transmission speed is directly related to the copper loop length and gauge (see table below).

Type	Downstream Speed	Gauge 24 Cu	Gauge 26 Cu
ADSL	4 to 6 Mbps	12 Kft	9 Kft
ADSL Lite	1.5 Mbps	24 Kft w/o voice 18 Kft with voice	15 Kft

The large ILECs have announced massive ADSL deployment plans, but almost all deployment plans to date have been for ADSL over home run copper loops. ADSL can also be provisioned with a Digital Loop Carrier system. ADSL with DLC trials are being conducted by major carriers in hopes of announcing deployment plans by mid 1999 (see Appendix A). This topic is critically important because the number of lines served by

DLCs is expected to grow dramatically over the next few years,[4] and many new DLCs are likely to be placed in affluent suburban neighborhoods likely to be targeted by the LECs for DSL service.

ADSL with an ADSL-ready DLC

A Digital Loop Carrier is a cost-effective alternative to significantly improve transmission on long loops and to avoid expensive copper feeder on shorter loops. A DLC provides a high-speed digital transport between the central office and a DLC Remote Terminal (RT) with a copper pair extending to the home from the DLC cabinet.[5] The design characteristics of DLCs usually mean that the copper portion of the loop is shorter (usually < 12,000 feet) and free from load coils and bridge taps. While the older DLCs and many current ones are not ADSL-ready, the latest DLC products are designed with broadband application in mind and can provide ADSL service with simple plug-in cards (see Appendix B).[6]

Figure 2 shows how ADSL can be provided over a DSL-ready DLC using the latest equipment.

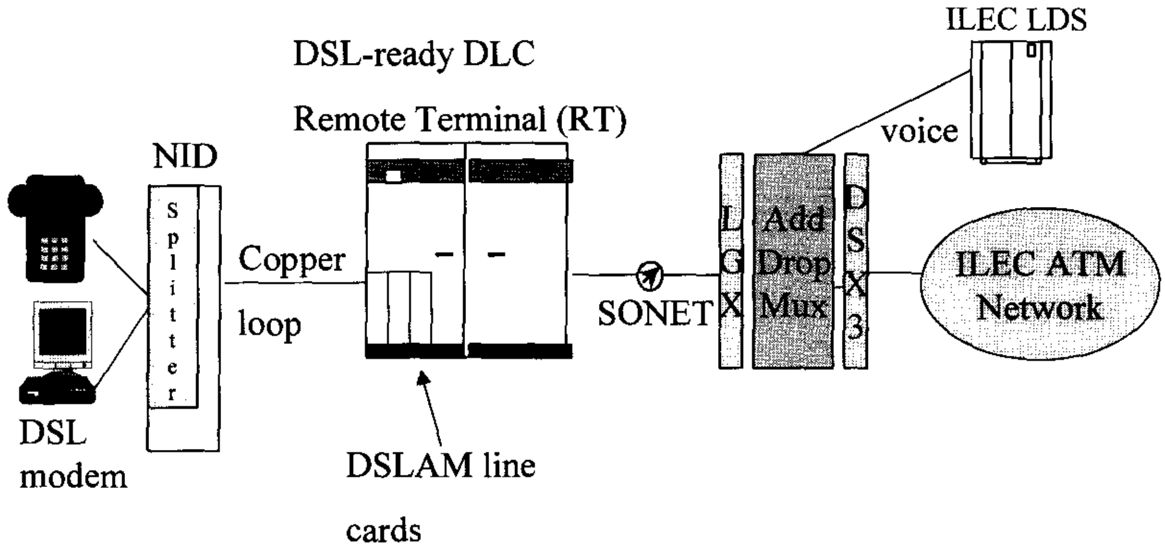


Figure 2 ADSL with a DSL-ready DLC

[4] See, for example, DLC Trends presentation by Bellcore at GR-303 Integrated Access Symposium, San Diego, CA, July 29-30, 1998 - www.bellcore.com/gr/GR303.html#forum. Nationally, the average annual increase in DLC served lines is approximately 20 percent, compared to an annual growth in access lines of 3 to 5 percent.

[5] Copper distribution is still the most economical way to provide POTS service. For more information, see MCI WorldCom's *Unbundling Digital Loop Carriers* White Paper.

[6] For example, Lucent AnyMedia, Litespan ADSL, AFC UMC 1000, and Fujitsu FACTR.

As the mixed voice and data signal travels from the customer premises to the central office, it is first combined by the splitter at the customer premise. It goes over copper wires to the DLC RT. Here the mixed signal hits a Digital Subscriber Line Access Multiplexer (DSLAM) line card. The DSLAM line card separates the voice traffic from the data traffic by using a splitter and aggregates many ADSL signals together. A splitter is a passive electrical device that filters out signals based on frequencies and splits the lower frequencies that carry the voice from the higher frequencies that carry data.[7]

The voice signal is digitized and sent over DS1 groups in a Time Division Multiplexed (TDM) format to the central office. The data is received from the DSL modem in an ATM[8]cell stream, taken off of the ADSL line, combined/muxed onto a shared ATM transport facility that could be DS-1, nxDS-1 IMA, DS-3, or OC-3c. Both the voice and data facilities travel over a high capacity OC-3 (155 Mbps) or OC-12 (622 Mbps) pipe to the central office. While the voice and data signals travel on separate DS1 or OC-n groups, they can both be physically on the same SONET fiber feeder transport to the central office.

At the central office the SONET transport system first hits a Light Guide Cross-connect (LGX) which is basically a MDF for fiber strands (refer to Figure 2). The signal then travels to the SONET Add-Drop Multiplexer (ADM) which moves traffic on and off the SONET transport system while simultaneously allowing other traffic to flow through. From the SONET ADM, the voice traffic, which is encapsulated in DS1 groups, can be sent to the ILEC or CLEC voice switch. The data traffic, however, needs to go to the data network.

The data traffic goes through a digital signal cross-connect (DSX)[9] patch panel (a passive electrical device that allows manual cross-connects for DS1, DS3 or higher level signals) and then on to the core ILEC ATM data network (see Figure 3) where the ILEC ISP typically connects its POP (shown as ILEC.net). In cases where the DSLAM WAN port is greater than a DS-3 (e.g., OC-3), the data traffic may come directly off of the LGX.

[7] The voice signal travels in the first 4 khz frequency range and the data in the upper frequency range (up to 1.2 Mhz).

[8] All RBOCs have adopted an ATM format for the DSLAM output and many other ILECs are moving towards that standard.

[9] A DSX-3 is used for DS3 level signals while a DSX-1 is used for DS1 level signals.

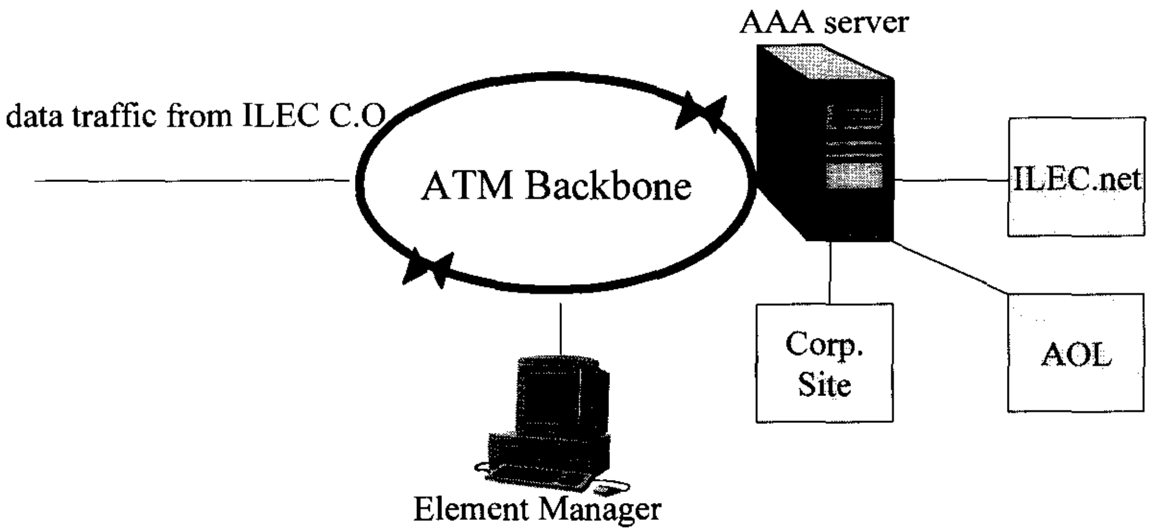
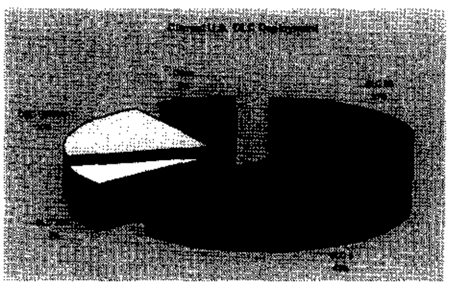


Figure 3 ADSL data flow

Prior to accepting the data, an ISP may ask the provider to authenticate the signal, provide security checks and aggregate ATM sessions using an Authorization Accounting and Authentication (AAA) server[10], or the ISP may do these functions itself.

ADSL THROUGH A LEGACY DLC

While DSL-ready DLCs can easily handle ADSL signals, they are a recent innovation; most are just now being field tested. The embedded base of DLCs[11] was designed for voice and ISDN services using a 64 Kbps backplane[12] and cannot support broadband services (see Figure 4).



Source: Westell

Figure 4 Embedded DLC Deployment

[10] The AAA server may be owned by a CLEC or an ISP and is not necessarily a part of the ILEC network.

[11] Of the approximately 35M lines served by DLC, 7.5M are SLC96, 15M SLC5, 2.5M SLC2000, 7M DSC Litespan and 3M Others (Nortel, Fujitsu, AFC, Reltec, etc.). Source: Westell, Commercializing DSL Technologies presentation, September 25, 1998, Atlanta GA.

[12] A backplane is the main electronic printed circuit board in a communications equipment cabinet that has slots or connectors for circuit boards to be plugged into and is an integral part of the system.

They can, however, be retrofitted (even the older Universal DLCs) to handle ADSL signals. Many Integrated DLCs (IDLC) can be retrofitted to support ADSL through an infrastructure upgrade. Retrofitted solutions must deal with space limitations in and around the cabinet and city ordinances limiting devices next to DLCs. There are three common ways to retrofit integrated DLCs for ADSL.

Remote DSLAMs

The central office's DSLAM functionality can be brought to the RT site by having a separate CO size DSLAM adjacent to the field RT. The DSLAM can be environmentally hardened and placed in a cabinet close to the RT. Remote DSLAMs can handle additional lines by simply adding extra plug in cards and can take advantage of a CO based network management system. For example, a typical remote DSLAM can serve 48-96 ADSL lines. The disadvantage to this solution is primarily cost.

The installation of a remote DSLAM may require rights of way, pouring of a concrete pad, installing and powering the adjunct cabinet where the remote DSLAM is to be housed and wiring to the existing RT. This solution must also add cross connects to the remote DSLAM which takes the copper pair and splits out the POTS traffic but then the pair that contains the POTS traffic must be routed back to the DLC cabinet. This involves an additional cross connect that was not originally needed for POTS-only service. Since legacy DLCs were built with few spare terminations, additional cross connect blocks may have to be added. The provider may also have to channelize the fiber feeder unless spare fiber pairs are available.

To reduce the costs associated with an adjunct cabinet, it is possible for remote DSLAMs to be mounted inside the cabinet door of the original DLC. Such configurations are sometimes called wart cabinets, pregnant doors or blisters. This solution, however, is rarely used because it may interfere with the cabinet's physical integrity and disrupt existing service. As an example, the extra holes in the cabinet door may no longer allow the DLC cabinet to be waterproof.

A remote DSLAM solution is an excellent choice for an ADSL service provider at larger DLC locations, but may not be appropriate for smaller line DLCs because of the high up-front investment.

Plug-In Cards

ADSL plug in cards are available that can be placed in spare slots of legacy systems. This eliminates the need for adjunct cabinets and the associated power and installation. However, in legacy systems the DLC may require significant rewiring and backplane upgrades, depending on the vendor, and most systems configured this way will only have a DS1 output.

Since the legacy DLC backplane was not designed for broadband services, it must now be upgraded. This process involves shutting down the DLC, putting customers out of service, removing the shelf if the DLC is in a cabinet, and installing a new backplane. All of this can take several hours during which customers will not have service.

The power supplies must also be upgraded and heat dissipation must be accounted for since ADSL has higher power requirements than POTS. [13] Additionally, if plug-in cards are used for ADSL, the slots are no longer available for the voice services the DLC was originally engineered for.[14]

In the case of the newest DSL-ready DLCs, however, plug in cards can make ADSL deployment quick and ubiquitous. As an example, the Litespan ADSL supports ADSL line cards with four ADSL lines per card without concentration.

Remote Access Multiplexer (RAM)

Remote Access Multiplexers (RAM) allow embedded DLCs to support ADSL. RAMs can be pizza box sized or just a downsized version of a CO DSLAM and can be rack mounted inside the DLC cabinet[15]. The copper loops coming in to the DLC get connected to the RAM through the protector block[16] (see Figure 5).

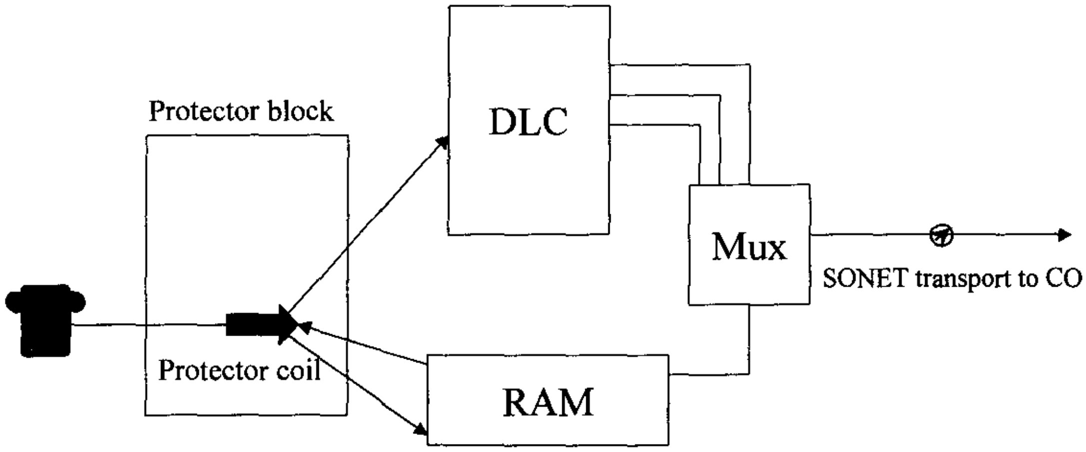


Figure 5 RAM wiring in a DLC

[13] This is true for any in-cabinet retrofit solution since additional equipment is being placed.

[14] See http://www.lucent.com/netsys/supercomm/adsl5.html. "Lucent and Westell Technologies, Inc. together have developed a plug-in ADSL solution for our SLC®-2000 and Series 5 Carrier Systems. The solution is based on DMT line coding and ATM transport protocol and is capable of being configured for full-rate or Lite ADSL service. The solution consists of Central Office based equipment that provides the interface to the data network. It includes the DSLAM LinkReach Access System, a standalone DSLAM for the Central Office, and an ADSL channel unit and statistical multiplexer located in the SLC remote terminal. Each channel unit contains two ADSL lines per card and fits into three vacant SLC channel unit slots, so you can use your existing power source and minimize your use of floor space, with no need to purchase more real estate or expensive cabinets. You can put your spare capacity to good use delivering ADSL in those low-take-rate areas without expensive overlays."

[15] One vendor estimated an hour for the entire installation.

[16] All outside copper loops need to be protected from lightning by protector coils.

A passive splitter in the RAM separates the voice traffic and sends it back to the DLC.[17] The data traffic travels through a DS1 User Network Interface (UNI) to a DS1 extension line card on the mux in the DLC. The voice and data travel over separate DS1s within the same fiber feeder transport to the CO. In the CO they are demuxed and sent to their respective voice and data switches. A RAM performs DSLAM functionality but it is not a CO size DSLAM. RAM devices leverage the DLC's power source and can be battery or AC powered.

While RAM installation doesn't require tremendous upgrades, they currently do not serve many lines without having to add another device. A typical device allows as few as 1-8 and as many as 24-48 subscriber lines to be connected to it (see Figure 6).[18]

PulseCom RAM 1100

PairGain Avidia 2200 RT

Courtesy of PulseCom and Pairgain

Figure 6 Sample RAMs

This means that in the case of a RAM that supports 8 lines, a new RAM must be placed in the cabinet for the ninth subscriber and will require another empty slot in the cabinet. Even though RAM capacity is currently an issue, it is being addressed by the industry with newer denser RAMs. Some vendors plan to increase the number of subscribers supported to 24 G.lite subscribers by the first quarter of 2000.[19] Compatibility with CPE is also an issue but one that can be addressed by RAMs that are software downloadable. RAM capacity is also affected by the output data speed. In this example, that speed is limited to DS1. Higher speeds are possible by adding fiber channelizing equipment at additional cost. In some retrofit solutions, the mux may have to be upgraded or additional fiber may have to be lit to support the extra backhaul bandwidth needed.

INTERCONNECTION OPTIONS

There are several ways for CLECs to technically interconnect with the ILEC. CLECs can interconnect in (a) the field by collocating at the Remote Terminal, (b) the ILEC central office; or (c) parts of the core ILEC network.

[17] Splitters can be external as well and/or be mounted on the protector block.

[18] For example Pulsecom's WavePacer RAM-1100 measures 1.75" high and 17" wide and lists for $5,995. For more information see PulseCom's RAM tutorial at www.webproforum.com. PairGain's Avidia 2200 RT supports 12 ADSL and POTS lines, is 3.5" x 23" x 12" and lists for $20,455 fully loaded. Other vendors include Nokia (formerly known as Diamond Lane Communications) with their Micro-RAM24 and Alcatel.

[19] Increasing the number of full rate ADSL subscribers is more challenging because full rate ADSL chip sets have high power requirements.

Collocation at the Remote Terminal

Regardless of the type of DLC, the Remote Terminal offers a technically feasible interconnection point. The table below shows an approximation of the types of DLC cabinet environments.

Type	Typical lines/site	Percentage
Indoor equipment rooms	Tens of lines	~5%
Fiber To The Curb	Tens of lines	~1-2%
Pad and pole mount	Hundreds of lines	~85%
Above ground huts and Controlled Environment Vaults (CEV)	Thousands of lines	~10%

Source: Estimates by Nokia High Speed Access, DSLCon Spring 99, April 15, 1999 in Dallas TX.

As can be seen from the above table, the vast majority of DLC cabinets are on pads or pole mounted both of which have great space limitations.

One way for CLECs to provide ADSL from DLCs is to get the copper loop that terminates at the DLC and use their own facilities for the electronics and transport. CLECs can access the copper loop by having the ILEC perform a cross-connect at the RT (sub-loop unbundling) over to a CLEC position on the cross-connect panel[20] in the cabinet.

This process is essentially collocation at the RT. The CLEC must lease space in an ILEC cabinet, or most often, install a separate cabinet next to the ILEC RT to house its DSLAM and multiplexing equipment and have it cabled over to the ILEC cabinet. This is similar in concept to a central office collocation where a CLEC collo must be cabled over to the ILEC MDF. As in the central office case, once the CLEC gets the copper loop, it must perform the DSLAM function, multiplex the signals and transport them to its own central office.

CLECs can transport their signals by either using their own transport to their central office or have their signals go through the ILEC multiplexer in the DLC and be transported over a shared feeder to the ILEC central office. This is feasible if the multiplexer can support this configuration and has spare ports available. The CLEC can then pick up its traffic in the central office. If, however, CLECs choose to provide their own transport, they must provide separate transport from each collocated RT to their central office.

Establishing a separate cabinet can be time consuming and expensive and spare cross-connect blocks may not be initially available. There may also be no room around the DLC for adjunct cabinets. This interconnection option, however, has the advantage of a CLEC being able to offer ADSL without the ILEC having to deploy it first.

[20] This assumes cross-connect panels are available. Since DLC cabinets were not originally designed for competition, an access device or panel may need to be added. While this is technically feasible, it may not always be economically efficient.

Another method is for CLECs to install their own ADSL plug in cards or RAM into the existing ILEC DLC. The CLEC could install and maintain the equipment themselves or purchase the equipment and have the ILEC maintain the equipment for them (virtual collocation at the RT). As explained above, the CLEC still has to get its signal to its central office.

All of the collocation methods at the RT face potential space constraints. One solution is for an ILEC to install a broadband DSL-ready DLC sized for future demand and have CLECs interconnect in the central office and other core network points. This eliminates the problem of multiple CLECs all trying to physically collocate at various Remote Terminals, but introduces the question of whether an ILEC will actually deploy equipment that fosters competition.

Central Office

If CLECs want to interconnect in the central office, they can access *voice* signals directly off of a port on the ADM or at the DSX-1 patch panel (used for manually cross connecting DS1 level signals) through a channelized DS1. The latter configuration is more prevalent and is discussed extensively in MCI WorldCom's *Unbundling Digital Loop Carriers* white paper. Unlike voice signals which can travel over separate DS1 groups, current DSLAMs limit their data output to a single Wide Area Network (WAN) card[21] so that all customers' data, regardless of the destination network, travel co-mingled over the same wide data pipe to the central office. As a result the *data* traffic must be received at other network points and is discussed later.

A possible way of receiving data traffic in the central office in the future is to access the traffic coming off of a multiported DSLAM that can separate the data bit streams from different providers. While these DSLAMs don't exist today, some vendors are working on this solution and industry experts expect product availability in approximately 12-18 months. Once these DSLAMs are implemented, CLECs can take their traffic off of the DSX-3 (or LGX) in the ILEC CO (refer to Figure 2).[22]

Another method of central office interconnection is for CLECs' DSL customers to be served on spare copper loops from the RT to the central office. This is similar to a home run copper case, and the CLEC must have a collo and provide its own facilities. Since DLCs are often placed because there are few spare pairs available, this option may not be very viable. Also, DLCs are typically used for longer loops, so the length of the spare copper pair added to the distribution distance might very well make the loop too long to support ADSL.

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[21] Ericsson and a few other vendors have recently announced DSLAMs that support multiple WAN cards. Typically it is better for each WAN card output to have its own separate transport to the CO; the different WAN outputs, however, can be integrated into the main DLC feeder transport.

[22] It is not clear, however, whether a CLEC would prefer this option since it would require some type of transport to each CO offering ADSL where it expects customers. With other options the CLEC only has to provide transport from a central location to its own ATM POP.

Other Network Points

If a CLEC chooses not to deploy its own transport from the RT, but instead shares transport over a common ILEC feeder, then the CLEC must interconnect at other network points to get the *data* traffic. As explained earlier, current DSLAM products co-mingle all parties' data traffic. Therefore, until mutli-ported DSLAMs are available, a device such as an ATM edge switch is needed to separate the data bit streams.

The ATM edge switch is so named because it sits on the edge of a core ATM network and is typically a small ATM switch that separates the data traffic from all the carriers and routes each one to its final destination (see Figure 7). The output of the edge switch can go to a CLEC ATM POP but is also linked to the ILEC core ATM network where ISPs typically connect their POPs. If the CLEC has an ATM network, it can simply buy a port on the ATM edge switch and take its traffic from there to its own ATM POP (refer to Figure 7). Until there is more demand for ADSL, it may be more cost effective to place the edge switch in a central location as opposed to in each central office.

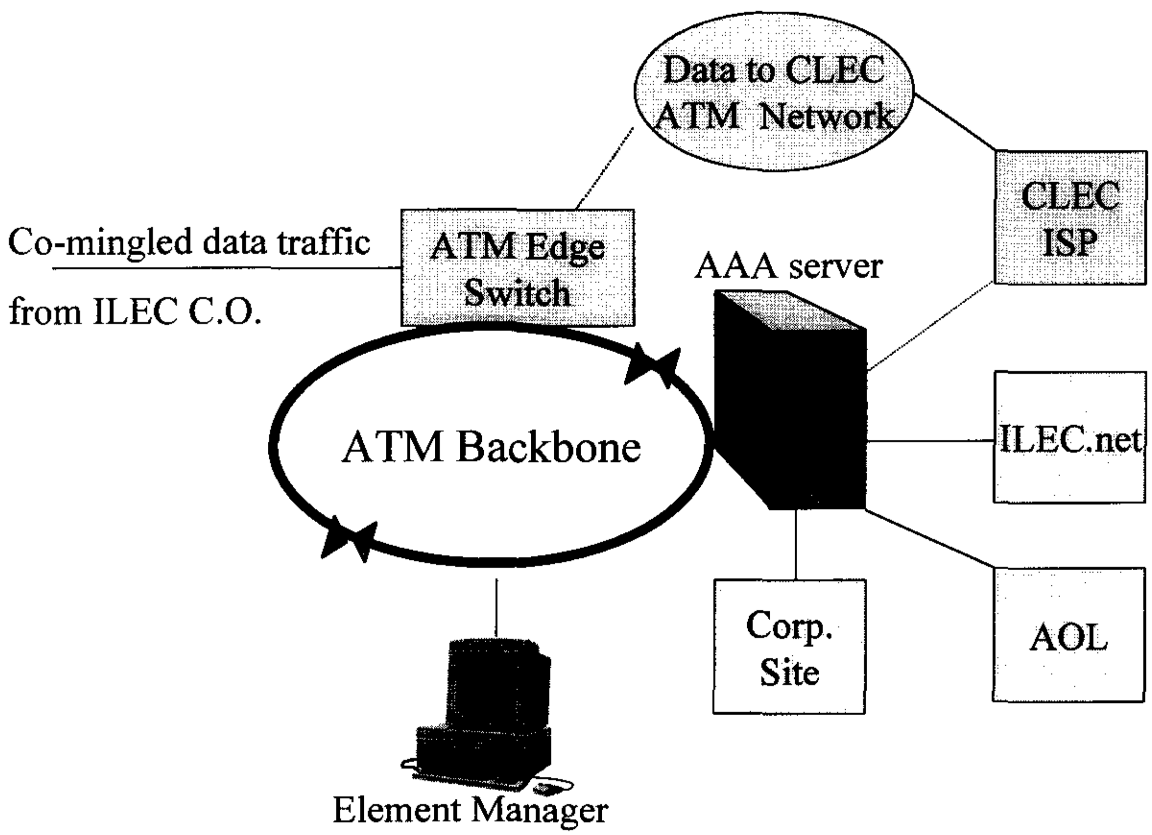

Figure 7 Core network interconnection

CLECs that don't have their own ATM networks can pick up their traffic off of a port on either the core ILEC ATM network switch or the AAA server if the ILEC has one (refer to Figure 7). This option, however, relies on the ILEC deploying an efficient ATM network configuration that easily accommodates CLEC interconnection.

The interconnection options are summarized in the table below.

Interconnection Option	*Pro*	*Con*
Spare home run cooper loop	Don't need RT collocation	Need to collocate in CO. Loop may be too long to support ADSL.
Copper loop at the RT	CLECs can offer ADSL without ILEC first having to do so.	Need adjunct cabinet to house CLEC DSLAM and mux. Need transport to CLEC CO.
ADSL plug-in or RAM at RT	Don't need adjunct cabinet. Plug-in cards can easily add customers. RAM fits in existing cabinet.	Investment/subscriber may be high. Plug-ins use up slots designed for voice services. Need transport to CLEC CO. Must account for additional power and heat requirements.
Get port on ADM (voice) and DSX-3 (future)	Don't need RT collocation	May have to have transport to each CO. Assumes ILECs will actually deploy multiported DSLAMs when available.
Get port on ADM (voice) and Edge Switch	Don't need RT collocation. Only need transport to one central location for data traffic.	Need your own ATM network. Contingent on ILEC deploying proper equipment. May have to pay high port/transport charges.
Get port on ADM (voice) and core ILEC ATM network	Don't need RT collocation. Only need transport to one central location for data traffic.	Contingent on ILEC deploying proper equipment. May be paying for inefficient ILEC ATM network.

CONCLUSION

ADSL does not have to be limited to home run copper applications. ADSL with a DLC is currently in trial stages and has promising results. As the number of lines served by DLCs increase, this method of DSL deployment will become increasingly important.

There are a few different solutions to provide ADSL with a DLC. The cleanest option is to deploy the latest generation of broadband digital loop carriers. Other options include installing a remote DSLAM at the RT, using ADSL plug-in cards in existing slots in the DLC and placing a RAM device inside a DLC cabinet.

In order to bring competition to advanced services and not be limited to pure copper loops, CLECs must have access to the incumbent's network at all technically feasible points as discussed in this paper.

To facilitate competition, regulators should allow:

1. CLECs to collocate at the RT – both physically and virtually to either install their own DSLAMs, DSLAM line card or RAM device;
2. CLECs to share cabinet space with the ILECs;
3. CLECs access to the RT to provide their own transport to their facilities;
4. CLECs to get transport bandwidth within an ILEC feeder; and
5. CLECs to interconnect in the central office and other technically feasible points in the core network to pick up their traffic.

Without non discriminatory access to the elements needed to provide ADSL, CLECs will be at a disadvantage in bringing advanced services to the marketplace and will have to rely on home run copper solutions which necessitate central office collocation and will not be usable where the customers are too distant from the CO. ILECs, on the other hand, will be at a competitive advantage to provide advanced services to a growing and potentially more profitable market segment.

For further information, contact:

Chandan Choudhary
Senior Policy Advisor
MCI*WorldCom*
1801 Pennsylvania Avenue #425
Washington, D.C. 20006
(202) 887-2667
Chandan.Choudhary@wcom.com

Appendix A – Excerpt from US West October 28, 1998 Announcement

Extending the Range and Reach of MegaBit Services

Today, 213 central offices are already equipped to support MegaBit Services in more than 40 cities across U S WEST's region. To further extend MegaBit Services availability within those communities, U S WEST will equip 40 additional central offices in early 1999.

In addition, U S WEST will increase the percentage of customer lines in central offices capable of supporting the service. In the first quarter of 1999, U S WEST will begin targeted deployment of remote services solutions that enable customers currently *served by Digital Loop Carriers (DLCs)* [emphasis added] to get MegaBit Services. DLC is a fiber-to-the neighborhood transport technology that is often used to provide phone service to newer housing developments and business parks. The solution initially involves placing MegaBit equipment in the field adjacent to metal cabinets that house DLCs, or directly in multi-dwelling units and large business complexes to ensure that all tenants' telephone lines are capable of supporting exceptionally high-speed data access.

U S WEST is also working closely with Cisco Systems to deploy technology that extends the distance customers can live from their central offices and qualify for MegaBit Services - from about 15,000 to 17,000 feet early next year, with additional improvements on an ongoing basis.

With these enhancements, U S WEST will increase the percentage of telephone lines qualifying for MegaBit Services in central offices equipped for the service, to nearly 50 percent on average, up from about 30 percent today.

Appendix B – Industry announcement on ADSL and DLCs

Ubiquitious DSL Deployment Now Possible With Highly Integrated Digital Loop Carriers Check It Out

URL: http://www.xdsl.com/today/news/story.shtml?918481998

February 8, 1999 -- The Digital Subscriber Line (DSL) market just got another boost today by way of Digital Loop Carriers (DLCs). Centillium Technology Corporation announced that Advanced Fibre Communications®, Inc. (AFC) has selected the Centillium CopperLite chipset for the G.Lite ADSL (G.922.2) plug-in card for AFC's flagship product, the UMC 1000 Multi-Service Access Platform. As a leading manufacturer of networking equipment for the "local loop" between telephone service users and public telephone networks, AFC's adoption of the Centillium CopperLite chipset is expected to enable telecommunications carriers to deploy low-cost, high-performance DSL services to worldwide markets more rapidly and cost-effectively than ever before.

DLCs are quickly becoming the prevalent technology for delivering voice and data services over "last mile copper networks" in every part of the world. In the United States, greater than 20% of local telephone lines terminate in a DLC, including up to 70% of all new line growth. Until now, however, carriers have been unable to cost-effectively deploy DSL line cards in remote cabinet DLCs due to severe power, rack space, and temperature constraints.

The UMC 1000 from AFC overcomes these challenges with G.Lite DSL plug-in cards based on the CopperLite chipset. The Centillium chipset supports the industry's highest port density -- up to eight DSL ports per chipset -- enabling AFC to provide more DSL lines using less rack space in a small DLC. The CopperLite chipset also eliminates costly infrastructure upgrades by offering the industry's lowest power consumption (0.65 watts/per port) and ensures software upgradability over time by delivering ample processing power.

"Both large and small telephone companies worldwide tell us that speed and profitability are critical to their success in deploying DSL services," said Philip Yim, Director, Product Planning, AFC. "To achieve rapid deployment of DSL in the local loop, carriers must be able to upgrade their existing infrastructure instead of building an entirely new one. AFC is committed to providing solutions compliant with the emerging G.Lite standards, which will accelerate and ease deployments of ADSL services. This new solution from Centillium and AFC allows carriers to leverage their installed base of existing equipment simply by adding new G.Lite DSL plug-in cards to their DLCs."
"The power, temperature, and rack space requirements are far more limiting for a DLC in a remote cabinet than for a DSL Access Multiplexer in a central office," said Al Gharakhanian, Director of Marketing for Central Office Products, Centillium

Technology. "The highly integrated CopperLite chipset, combined with the innovative and flexible architecture of AFC's UMC1000 platform, has removed one of the last barriers to mass deployment of DSL technology in both DLCs and central offices."

Centillium CopperLite Delivers DSL in Digital Loop Carriers

The two-part CopperLite CO (central office) chipset consists of the CT-L10DC08 Digital chip and CT-L10AC08 Analog chip. Networking equipment manufacturers can use these cost-effective, power-efficient chip sets as the foundation for multi-port line cards in both carrier-class DLCs and DSL Access Multiplexers (DSLAMs). In addition to AFC, several other major manufacturers of telecommunications equipment have standardized on Centillium's CopperLite CO chipset.

The CopperLite CO chipset is highly integrated and offers maximum port density, supporting up to eight DSL ports with just two chips. Very low power requirements help keep power dissipation to just 0.65 watts per port. The CopperLite CO chipset is based on Centillium's software-upgradable Communications DSP, which ensures long product life cycles without the need for costly hardware upgrades. The chipset provides end users with high-bandwidth Internet access at speeds of 1536kbps downstream and 512kbps upstream over "Plain Old Telephone Service" (POTS) regular copper phone lines. That is up to 27 times faster than conventional 56kbps analog modems.

About Advanced Fibre Communications, Inc.
AFC is a leading manufacturer of telecommunications systems for the "local loop" between telephone service users and public telephone networks worldwide. AFC has pioneered a single platform that supports any network, any transport, and any service. AFC's flagship product, the UMC 1000® Multi-Service Access Platform, provides any service from POTS to xDSL over copper, fiber, and wireless transport media. AFC has deployed over 2 million access lines worldwide. Additional information about AFC can be found on the Internet at http://www.fibre.com.

About Centillium Technology
Founded in April 1997 and headquartered in Fremont, California, Centillium Technology is the world's leading innovator in the emerging market for Digital Subscriber Line (DSL) chipset solutions. Centillium Technology is a fabless semiconductor company developing G.Lite-compliant DSL solutions for manufacturers of telecommunications equipment. Centillium's CopperLite Central Office (CO) and Customer Premises Equipment (CPE) chipset family is the industry's first end-to-end DSL solution specifically designed for mass consumer markets. Centillium's CopperLite CO and CopperLite CPE chipsets are available to networking equipment manufacturers today. Additional information on Centillium is available at http://www.centillium.com.

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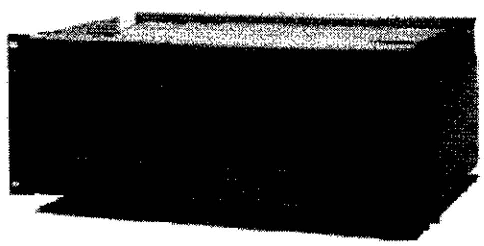
Law and Public Policy

Unbundling
Digital Loop Carriers



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I. INTRODUCTION

The purposes of this paper are to show:

- that Integrated Digital Loop Carriers (IDLCs) can be unbundled;
- that there are four technically feasible ways of unbundling IDLCs with equipment that is in-place or generally available today;
- that CLECs can access their IDLC served customers' signals in a digital format *without* collocation; and
- that converting an IDLC-served customer to all copper facilities or an older form of DLC is a backward step in technology that actually degrades the customer's service.

Digital Loop Carriers are widely deployed in the telecommunications network in place of expensive copper feeder. In addition to providing a cost-effective alternative to copper feeder in many situations, DLCs can extend potentially distance-restricted services such as ISDN farther away from the central office and can push switch-based functionality farther into the field to remote terminals.

Currently, 20 percent of the access lines in the United States are served by DLCs, and that penetration is projected to increase ultimately to 50 percent in urban areas and 80 percent in rural areas.[1]

DLC technology has been around since the 1970s, but there have been significant advances in the technology over the past two decades. Today there are two major types of DLC – Universal (UDLC), which was developed for an analog environment but can work, albeit inefficiently, in a digital environment, and Integrated (IDLC), which was developed specifically for a digital environment. There have been two "generations" of IDLC technology, which conform to two sets of specifications developed by Bellcore -- TR-008 and GR-303.[2] The Bellcore GR-303-capable IDLCs are the forward-looking technology being deployed today.

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[1] GR-303 technology and its deployment were the topic of Bellcore's GR-303 Integrated Access Symposium, San Diego, CA. July 29-30, 1998. www.bellcore.com/gr/gr303.html#forum.

[2] Some manufacturers have called their GR-303 IDLCs "Next Generation DLCs" (or NGDLCs) for marketing purposes, but these simply represent the manufacturers' latest GR-303-compatible IDLC offerings.

UDLC enters the central office switch in analog form, and therefore requires an analog-to-digital conversion when used with digital switches. By contrast, IDLC stays in digital form as it enters the local digital switch. Today, an incumbent local exchange carrier (ILEC) is unlikely to deploy a UDLC unless an analog switch serves the loop(s).

The notion that IDLC technology cannot be unbundled because it is integrated into the local digital switch is incorrect. As this paper will show, "integrated" does not mean inseparable or incapable of being unbundled. It is technically feasible to unbundle all IDLCs, including TR-008 and GR-303 IDLCs.

While older DLCs were only designed for voice services, the most recent products are designed with broadband applications in mind and can simultaneously support voice as well as advanced technologies such as Digital Subscriber Line (DSL). This paper only focuses on unbundling the voice capabilities of Digital Loop Carriers. Another MCI WorldCom white paper on providing ADSL with a Digital Loop Carrier is under development and will be available shortly.

II. WHY LECs DEPLOY DLCs

A DLC is an electronic device that connects to customers' copper distribution pairs at a remote terminal, converts the analog signals to a digital multiplexed format, and then transports the digital signal over a fiber or copper transport to the local switch in the central office. Figures 1 (a), 1 (b), and 1 (c) show three scenarios that will be described in greater detail in this paper: UDLC connecting to an analog switch such as a Western Electric 1AESS or crossbar; UDLC connecting to a digital switch; and IDLC connecting to a digital switch.

The multiplexing of the copper pairs reduces the number of pairs needed in the feeder portion of the loop plant (or eliminates the need for copper pairs altogether in the feeder network as they are replaced by fiber). Indeed, for that reason, when DLC technology was first introduced it was often referred to as "pair gain" technology. In addition, DLCs are often more economical to deploy for feeder lengths greater than 9,000 feet than are large, expensive copper feeder cables. Companies sometimes perform a cost-benefit analysis to prove in DLCs by comparing the DLC costs to the cost savings from not having to reinforce existing cables or not having to obtain additional room on poles or place additional conduits.

Also, deployment of DLCs in concert with the Carrier Serving Area (CSA) and/or ISDN design criteria developed by the industry, allows a carrier to provide digital services such as ISDN service that cannot otherwise be provided over loops that exceed 18,000 feet (see Figure 2).[3] In addition, DLCs bring some switch-based functions out to the field. For example, many GR-303-equipped DLCs poll customer lines for an off-hook condition, perform concentration functions, and extend services such as ISDN further out into the central office serving area.

III. UDLC vs. IDLC

The first generation of DLC, now known as UDLC, consists of a remote terminal (RT), a transmission (transport) facility to link the RT to the central office (CO), and a central office terminal (COT). (See Figures 1 (a) and 1 (b).) The RT aggregates the copper pairs and performs conversions -- converting the customer's analog signal to a digital multiplexed format going to the central office, and (in the opposite direction) converting the digital signal from the central office to the customer to an analog signal. The transport carries the digital signal from the RT to the COT, and vice versa. The COT equipment converts the digital signal from the RT to an analog signal before the signal is terminated on the Main Distributing Frame (MDF)[4] and cross-connected to the switch port.

It is at this point that the equipment needed differs depending on whether the CO switch is analog or digital. Where a UDLC is connected to an analog switch (see Figure 1 (a)), after the individual voice-grade analog circuits are terminated on the MDF, they are cross-connected into and out of the switch through an analog line circuit card.

In the case where a UDLC is connected to a digital switch (see Figure 1 (b)), the signal is cross-connected on the MDF to an analog port (called an Analog Interface Unit or AIU) on the switching system. At the AIU, the signal that was converted from digital to analog at the COT is now converted back to digital -- and, in the other direction, the digital signal from the switch is converted to analog before being sent to the COT where it will be converted back to digital.

As digital switches were deployed, the required digital-to-analog conversion at the central office for UDLCs became redundant, inefficient, expensive and degraded voice quality. Thus, the "integrated" DLC was developed and introduced.

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[3] The CSA design copper loop limit is 12,000 feet with limited bridged taps. ISDN design specifies that loops be less than 18,000 feet, non-loaded, and have limited bridged taps (over 24 AWG wire). Both the CSA and ISDN designs enable more efficient and cost effective deployment of DLC technology, make more efficient use of the in-place cables, and reduce ongoing cable reinforcement costs.

[4] The COT equipment also converts the analog signal coming from the switching system to a digital signal to be sent to the RT.

The term "integrated" DLC was coined to differentiate the IDLC from the older UDLC technology. Specifically, it allowed the elimination of the DLC central office terminal, of switch line cards, and of the central office analog-to-digital (A/D) or digital-to-analog (D/A) conversions. In short, the IDLC could be directly connected to the digital switching system. However, this does not mean that the DLC is inseparable, indivisible, or incapable of being unbundled, nor that the service is inseparable from the ILEC switch. As will be described in detail below, an IDLC can be digitally connected to more than one switch simultaneously (this is called Multiple Switch Hosting) by separating and unbundling digitally encoded voice (and data) channels.

As shown in Figure 1 (c), the basic IDLC system consists of an IDLC RT, a digital transmission facility with various pieces of equipment and an Integrated Digital Terminal (IDT) in the switch.

The IDLC RT (see Figure 3) consists of channel units (customer interface cards), power supply, a Time Slot Interchanger (TSI) that assigns loops to time slots, interface groups that aggregate traffic into specific interface formats,[5] and a multiplexer (mux) to consolidate or aggregate the signals for transport to the CO. These main components of an IDLC RT are all contained within a cabinet that ranges from the size of a Network Interface Device (NID), a wall mount, to a large wall-to-wall bookshelf (for example, a Lucent 80D cabinet) depending on the vendor and number of lines served. Currently IDLC RTs can handle from 24 to 2,016 lines. Copper distribution cable, as opposed to coax or fiber, connects the customer to the RT and is still the most economical way to provide basic telephone service.

A digital transport facility connects the RT to the central office.[6] In the digital transport connecting the RT to the central office, various pieces of equipment

[5] These will be described in greater detail later and are shown in Figure 4.

[6] Early DLC applications used T-1 carrier on copper pairs. In addition to T-1 over copper, both Synchronous (SONET) and asynchronous fiber optic transport are utilized, depending on the application, size, location, and condition of the outside plant. Generally, larger DLC systems transport is on fiber at the SONET OC-3 (155 Mb/s or 84 DS1s or 2,016 DS0s) rate. In addition to OC-3, OC-1, OC-12, and DS-2 over fiber are also common options. SONET technology is preferred and has replaced other transport mediums because it dramatically reduces multiplexer costs and because of its inherent Add-Drop and Ring capabilities. Add-drop capability is the ability to accept or drop-off groups of circuits (virtual tributaries) from the SONET device without any additional multiplexing equipment while simultaneously providing transport to preceding and succeeding SONET muxes. Ring capability is the ability to connect multiple SONET muxes into one of several types of ring topologies such that service is maintained when one "leg" of the (ring topography) transport is severed. This is a common technique used to ensure survivability of the fiber transport.

must be used to de-multiplex (break down) the transport medium into individual DS1s in order to "hand-off" the DS1s to the digital switch. (See Figure 1 (c)). If the transmission medium is fiber, the signal goes through a Light Guide Cross-Connect (LGX),[7] a fiber multiplexer (mux),[8] and a digital signal cross connect (DSX) device. If the transmission medium is copper, the copper first terminates on the MDF (for lightning protection) and is then extended to the DSX. The DSX is similar to a MDF and allows DS1s[9] to be cross-connected to various devices in the CO. For either fiber or copper transport, the signal remains digital and terminates at the Integrated Digital Terminal (IDT) in the digital switch. The IDT is a digital interface component of the local digital switch where the DS1s from the IDLC RT are terminated and includes a Time Slot Interchanger that assigns loops to time slots on a per call basis.

Because of the digital nature of IDLCs, the MDF, which is the traditional demarcation point between the copper loop and the switch, is not the demarcation point for the IDLC-served loop. Instead, an IDLC loop is assigned electronically to time slots at the RT, and the physical demarcation point for an IDLC-served loop is in the CO at the Digital Signal Cross-Connect (DSX). The DSX is a passive electrical patch panel that allows manual cross-connects for DS1 or higher level signals. IDLC loops are transported in groups of up to 24 circuits within each DS1, which is typically terminated and cross-connected at the DSX.

From the DSX, CLECs can take their traffic to their CO over leased or owned transport without having to collocate. This option is particularly attractive to CLECs because collocation is expensive, time-consuming, and often said to be unavailable.

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[7] The Light Guide Cross-Connect is a device upon which the fiber from the outside is terminated and cross-connected with fiber "pigtails" to the fiber mux in the CO. The pigtails are single fibers designed to be inserted into the LGX to mix and match fiber inputs from the outside fiber cables. Essentially, the LGX is a fiber MDF.

[8] The fiber mux or SONET mux is a device that takes (electrical) digital signals (cross-connected via the DSX) and converts them into optical signals or vice-versa. For instance, an OC-3 mux can take a maximum of 84 DS1s and convert them into a single optical bit rate of approximately 155 Mbps with a multiplexing technique called Time Division Multiplexing, hence, the term mux. There are synchronous (SONET) and asynchronous muxes. An Add-Drop Mux (ADM) is a SONET mux that is capable of dropping off or accepting groups of DS1s while simultaneously providing transport to preceding and succeeding muxes.

[9] DS1s terminate on a DSX-1 and DS3s terminate on a DSX-3.

1. ADVANTAGES OF IDLC

Local loops connected to a digital circuit switch are provided more efficiently and cost effectively over IDLC than UDLC-provisioned loops because an IDLC requires neither an analog conversion at the CO, nor the AIU line card at the switch, nor manual MDF wiring. As a result, compared to today's IDLCs, UDLCs require a lot of unnecessary investment for digital-to-analog and analog-to-digital conversion equipment and MDF wiring in the central office. UDLCs also require substantial and unnecessary investment for switching equipment and the associated real estate and power requirements to convert the analog signal back to digital because today's digital switches require a digital signal.

In addition, the back-to-back digital-to-analog and analog-to-digital conversions inherent in the UDLC configuration reduce bit rate speeds for voice band data connections such as faxes or analog modems. Moreover, customers served by UDLC technology cannot receive ISDN and ADSL services without the installation of additional external loop electronics and digital transmission bandwidth at the UDLC, because UDLCs were neither designed nor have the capability to handle the bandwidth requirements of ADSL and ISDN.[10]

Consequently, the UDLC configuration is inefficient in today's digital network, would not be the technology of choice today for ILECs putting in additional DLCs served by digital switches, and does not represent a forward-looking technology.

2. TYPES OF IDLC CONFIGURATIONS

TR-008

The most prevalent IDLC configuration in place is the Bellcore TR-008 digital switch interface. This configuration evolved from the proprietary interface existing at divestiture, when the RBOCs had a large embedded base of Western Electric (now Lucent Technologies) SLC® 96 IDLCs that were only compatible with Western Electric switches.

With the break-up of the vertically integrated Bell System, the RBOCs could look to other equipment vendors. Given their large embedded base, these companies demanded that other switch vendors, such as Northern Telecom and Siemens

[10] Therefore, where ILECs have proposed to provide CLECs seeking unbundled DLC loops only UDLC loops, but not IDLC loops, CLECs would be precluded from offering ISDN and ADSL services over those loops.

Stromberg-Carlson, make their switch interfaces SLC 96-compatible. Because of this customer demand, Bellcore defined the TR-008 specifications so switch vendors could make their products compatible with the Western Electric SLC 96 IDLC. The existence of non-proprietary specifications helped spawn new DLC vendors. Today many vendors' IDLCs can integrate with the TR-008 digital switch interface. The TR-008 interface was vastly superior to UDLC systems, as explained earlier, and gave the telephone companies a choice in DLC equipment.

The TR-008 interface comes in two flavors: mode 1 and mode 2. Mode 1 provides no concentration while mode 2 provides a 2:1 concentration. Mode 1 consists of four DS1s (96 DS0s) that serve up to 96 lines resulting in one DS0 dedicated per line. Mode 2 uses two DS1s to serve up to 96 lines.

As Bellcore released the more technologically advanced GR-303 specification, many equipment manufacturers developed equipment to meet this newer specification.[11] Anticipating the release of the GR-303 specification, many built their TR-008 IDLCs such that they could be upgraded to GR-303. Consequently, many of the IDLCs deployed by ILECs today are capable of complying with both Bellcore's TR-008 and GR-303 standards. However, there are some older TR-008 IDLCs that cannot be upgraded to GR-303.

GR-303

In response to telephone companies' demand for an IDLC that could interface more efficiently than the TR-008 with the digital switch, and could extend the ISDN signal to customers served by facilities exceeding the maximum copper loop length requirements for ISDN, Bellcore developed GR-303. These specifications are defined in Bellcore's Generic Requirements "GR-303, Integrated Digital Loop Carrier System Generic Requirements, Objectives and Interface." GR-303 enabled the IDLC to dynamically allocate transport bandwidth by assigning a channel to a line on a call-by-call basis rather than dedicating channels to lines. It improved transport efficiency by extending the switch concentration ratio out to the IDLC. For example, at a 4:1 concentration ratio, a GR-303 IDLC can serve approximately twice as many lines as a TR-008 mode 1 (4 DS1s) IDLC, with half as many DS1s. That is, a GR-303 IDLC can serve 188[12] lines with 2 DS1s. The concentration ratio is also scaleable,

[11] Vendors and products include DSC Litespan 2000, Lucent SLC 2000, NORTEL Access Node, and RELTEC DISC*S. The latest IDLCs which can provide voice and advanced services such as DSL include Lucent's AnyMedia, Fujitsu's FACTR, AFC UMC-1000, and DSC's Litespan ADSL

[12] Twice as many lines would be 192 but four DS0s are reserved; one each for primary and backup EOC channels and one each for primary and backup TMC channels.

depending on the customer's traffic usage requirements.[13] As shown in Figure 4 and described in detail in Section IV, the GR-303 interface group can handle far more traffic than the TR-008 interface group. Also, GR-303 IDLCs efficiently support ISDN, resulting in more efficient transport and switching utilization.

The GR-303 interface has capacity for a minimum of two DS1s[14] and a maximum of twenty-eight DS1s. As shown in Figure 4, the first DS1 in the GR-303 Interface Group contains an Embedded Operations Channel (EOC) and a Time Slot Management Channel (TMC), and 22 channels available for customers. The EOC provides a communication path for operations and maintenance. The TMC assigns time slots for voice grade circuits and the ISDN B-channels. These functions – and thus the two channels – are needed for GR-303 to provide variable concentration and bandwidth assignment.

The second DS1 has backups for the EOC and TMC channels to provide redundancy, and 22 subscriber channels. The remaining DS1s do not need their own EOC or TMC, and thus each has the full complement of 24 channels.

As shown in Figure 5, the GR-303 IDLC RT can simultaneously accommodate TR-008 interface groups, GR-303 interface groups, and Integrated Network Access (INA) [15] interface groups. As discussed in greater detail in Section IV, this capability allows a GR-303 IDLC to integrate with several switches simultaneously.

The GR-303 IDLC technology provides a highly efficient and very powerful DLC network for local loops. Most GR-303 IDLCs have been constructed to support UDLC operation and/or TR-008 integration because manufacturers have had to be sensitive to carriers' embedded base of analog switches. While these GR-303 IDLCs can be configured to operate in UDLC mode, they are not UDLCs.

Many ILECs are deploying GR-303 capable IDLCs in their networks today,[16] and the trend is expected to increase because GR-303 is much more efficient, and

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[13] The concentration ratio is determined by the number of DS1s provisioned, which is engineered based on IDLC customers' traffic requirements and is usually engineered to the same requirements as a direct line-side analog interface at the digital switch.

[14] One DS1 may be used if redundancy is not required.

[15] INA will be discussed in the next section of this paper.

[16] See, for example, DLC Trends presentation by Bellcore at GR-303 Integrated Access Symposium, San Diego, CA, July 29-30, 1998 - www.bellcore.com/gr/GR303.html#forum. Nationally, the average annual increase in DLC served lines is approximately 20 percent, compared to an annual growth in access lines of 3 to 5 percent.

IDLC costs are decreasing while other outside plant costs increase.[17] Table 1, from the Bellcore DLC Trends presentation at the GR-303 Integrated Access Symposium, shows the percentage of working lines served by all DLC technologies and by GR-303-capable DLC, for the RBOCs and GTE. This suggests an overall DLC penetration rate of about 20 percent and a GR-303-capable DLC penetration rate of 10 percent.[18]

[redacted]	GR-303 Capable DLC	[redacted]
[redacted]	6%	[redacted]
[redacted]	18%	[redacted]
[redacted]	17%	[redacted]
[redacted]	6%	[redacted]
[redacted]	7%	[redacted]
[redacted]	3%	[redacted]
[redacted]	7%	[redacted]
[redacted]	10%	[redacted]
[redacted]	10%	[redacted]

3. Summing Up GR-303 Advantages

Bandwidth Efficiency

The GR-303 IDLC provides for significant efficiencies by moving the concentration function from the switch to the RT. GR-303 makes very efficient

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[17] Since the use of GR-303 technology requires both software and hardware upgrades to many embedded switches, at least one ILEC (PacBell) has stated that in many situations GR-303 does not "cost out" and therefore it does not intend to deploy it widely. This raises an important public policy issue. Is the PacBell decision based strictly on the merits of the technology or is it skewed by the strategic consideration that deployment of GR-303 will remove a barrier to competitive entry? That is, is a decision not to deploy the technology beneficial to PacBell shareholders but inconsistent with the public interest in fostering competition?

[18] Data presented by Westell at a recent DSL conference corroborates these numbers. Of the approximately 35 million lines served by DLC (out of approximately 172 million access lines nationwide), 7.5 million are SLC96, 15 million SLC5, 2.5 million SLC2000, 7 million DSC Litespan, and 3 million others (Nortel, Fujitsu, AFC, Reltec, etc.). Source: Westell, Commercializing DSL Technologies presentation, September 25, 1998, Atlanta GA.

use of the transport bandwidth medium and switch terminations by assigning a channel to the customer on a call-by-call basis as opposed to "nailing up" or dedicating the channel, as in TR-008. Hence GR-303 requires less bandwidth and switch terminating capacity than a TR-008 IDLC or a UDLC.

ISDN Provisioning

Prior to the availability of GR-303, ISDN provisioning on DLCs was expensive because it required using Basic Rate ISDN Terminal Extender (BRITE) plug-in cards. ISDN provisioning was inefficient because three DS0s with a total capacity of 192 Kbps were needed to carry the ISDN 2B+D channels with a total required capacity of 144 Kbps. Because GR-303 IDLCs are designed to deliver ISDN, ISDN can be provisioned easier and more efficiently than before because a single DS0 can be used to carry four D channels.

Optimizing OSS

GR-303 has been developed to operate in conjunction with forward-looking operations support systems such as OPS/INE, which provide for highly automated, centralized, and remotely located operations centers. GR-303 also supports digital connectivity for non-locally-switched services, such as foreign exchange lines, and non-switched services, such as Digital Data Service or DS0 private lines.

IV. UNBUNDLING ALTERNATIVES

Some parties have claimed that since an IDLC signal is digital and is connected to the switch IDT there is no way to unbundle the IDLC. They further contend that because it is allegedly technically unfeasible to unbundle IDLC loops, an ILEC customer currently being served by an IDLC loop who chooses to get service from a CLEC using unbundled ILEC loops could not stay on the IDLC loop. Rather, the customer's service would have to be put onto an analog loop (spare or retired copper loop or a UDLC).

In fact, there are no technical impediments to a customer receiving service from a CLEC via an unbundled ILEC IDLC loop as long as the ILEC controls and administers the RT and the network. If the ILEC manages the network (e.g., assigns CLECs to software groups in the RT, handles alarms, handles testing, etc.) it can simply hand off traffic to the CLEC through interconnection, which is done all the time today. If, however, CLECs want to jointly manage the RT, provision services themselves, handle their own alarms, etc. some technical problems may occur such as security and access to a single alarm group in the RT. These problems are being addressed by vendors and Bellcore's GR-303 Forum.

Unbundling of IDLCs is technically feasible, provides non-discriminatory access to end-to-end digital services, and is less disruptive to the customer than moving the service off of the IDLC. Placing an IDLC served customer onto a UDLC harms the customer because it is a lesser grade of service due to the extra analog–to-digital conversions required. The customer's analog signals would not be at parity with the IDLC-provided service. In addition, the customer probably would experience provisioning delays because UDLC or copper-fed service requires manual MDF cross-connects as opposed to electronic provisioning with IDLCs.

There currently are four technically feasible unbundling methods that can provide CLECs with non-discriminatory access to the customers served by IDLCs:

1. Multiple Switch Hosting
2. Integrated Network Architecture (INA)
3. Digital Cross-Connect System (DCS) Grooming
4. Side-Door Grooming

1. MULTIPLE SWITCH HOSTING

Multiple Switch Hosting is the ability of one IDLC RT to interface with multiple switches simultaneously. It allows the IDLC technology residing in the RT to serve the ILEC plus multiple CLEC switches.[19] Multiple Switch Hosting is possible because all GR-303 IDLCs have a Time Slot Interchanger (TSI) that allows a CLEC customer(s) to be assigned to CLEC-specific channelized DS1s served by the RT. That is, the ILEC and each CLEC can be assigned one or more DS1s (with each DS1 having up to 24 distinct DS0 voice grade channels), with their customer traffic routed to their assigned DS1s. This is accomplished by "field grooming"[20] at the RT – the process of using the TSI in the RT to map specific DS0s to specific DS1s or groups of DS1s, called "interface groups," as shown in Figure 5. If the customer changes his or her service back to the ILEC

[19] See DSC Communications web site http://www.dsccc.com/lsp2000.htm. "The Litespan can simultaneously support different switch interfaces from the same common control, making the system ideal for the transition to future network service and service to *multi-entity* [emphasis added] offices."

[20] The grooming is done in software and no field visits are ever required. Field grooming simply means that the grooming occurs electronically in the field as opposed to the central office.

or to another CLEC, field grooming allows the appropriate cross-connects to be made electronically in the same manner as described above.[21]

As mentioned earlier and shown in Figure 5, the GR-303 IDLC RT can simultaneously support interface groups for the TR-008 interface format, the GR-303 interface format, and the INA interface format. This Multiple Switch Hosting capability allows a single IDLC to interface with several ILEC and/or CLEC switches simultaneously,[22] with more than one type of switch interface (GR-303, TR-008, and/or INA) protocol. The Multiple Switch Hosting capability exists in most of today's IDLCs, and Bellcore's GR-303 specifications require the capability to be integrated with a minimum of two switches. Some vendors already provide Multiple Switch Hosting with up to five different switches and may soon be able to do so with up to eight.

Multiple Switch Hosting requires the use of one of the forward-looking operational support systems currently available, such as OPS/INE, and software provided by the IDLC vendor, in conjunction with the Time Slot Interchanger, to migrate a customer among local service providers.

First, the RT's Time Slot Interchanger electronically assigns the signal where it is placed on a DS1 in the appropriate GR-303, TR-008, or INA interface group. The traffic is fed into the RT's fiber mux and then transported over fiber (on a CLEC or ILEC channelized DS1) to the CO, where the fiber is terminated onto the LGX and cross-connected to the CO fiber mux (see Figure 6). The fiber mux decodes the optical signal into electrical DS1s that are then connected to the DSX patch panel, where the respective DS1s are handed off to the ILEC or CLEC equipment. The reverse is true for traffic flowing in the other direction. A CLEC can use leased or owned transport from the ILECs DSX panel to the CLEC CO, and interface the DS1 signal into its own IDT. This is the simplest and quickest option for CLECs to get the digital loop. Alternatively, a CLEC can take the DS1 signal from the DSX to its collocation cage. Collocation, while sometimes

[21] Field grooming at the RT requires that each customer be assigned a Line Circuit Address (LCA) and Call Reference Value (CRV). The customer's copper pair is terminated at the RT and is assigned a CRV in the appropriate GR-303 Interface Group, via the OSS interface. With multiple GR-303 Interface Groups, a CRV of any Interface Group can be assigned to the LCA corresponding to a customer's number. The GR-303 Interface Group uses the CRV in the Timeslot Management Channel to dynamically assign DS0s or fractional DS0s to a circuit on a call by call basis as directed by the TSI. This means, unlike TR-008, no DS0s are permanently assigned to any line. The CRV is assigned to an interface group (in software) to a LCA via a table in both the switch IDT TSI and the IDLC TSI. Figure 5 depicts a multi hosting capable IDLC.

[22] The number of integrated switches to a RT is a software capability inherent in the GR-303 specification.

desirable for things such as testing, is technically unnecessary for DS-1 level signals.

The Multiple Switch Hosting capability is the recommended forward-looking network architecture for unbundling in a competitive environment because, regardless of the local service provider, carriers have equal and non-discriminatory access to the capabilities of this highly efficient, high-quality digital local loop facility.

2. INTEGRATED NETWORK ACCESS (INA)

INA is an architecture inherent in IDLCs that allows specific DS0s to be mapped (groomed) into a unique interface group. This offers another method of unbundling GR-303 IDLC, albeit less efficiently than the GR-303 or TR-008 interface groups described by the Multiple Switch Hosting section above.

Originally, INA was designed to enable non-locally switched (FX service) and non-switched service (private line) DS0s to be terminated and redirected to the interoffice transmission network.[23] INA is another method of unbundling a GR-303 IDLC because the TSI can map (field groom) specific DS0s into specific Integrated Network Access groups as D4 formatted[24] DS1s. (See Figure 7.) This D4 format signal then goes to a CLEC "city ring" or collocation area where the INA DS1s are first terminated onto another IDLC (often called the unbundling RT) that converts the INA DS1 to GR-303 DS1s, which then go to the CLEC's switch IDT.

In this scenario, the CLEC would have the technologically feasible option of collocating or not collocating the unbundling RT. In most situations, it is more efficient for the CLEC to access the INA DS1s without any sort of collocation arrangement.

The INA option may force a CLEC to invest in an unbundling RT in its collocation area or CO, and therefore is less efficient than the Multiple Switch Hosting (GR-303, TR-008) solution. Multiple Switch Hosting is not widely available today, however, and in its absence some CLECs currently are using the (INA) unbundling technique to provide service to IDLC-served customers.

[23] Bellcore, GR-303, IDLC Generic Requirements, Objectives and Interface, page 1-3, paragraph 1.3.1.

[24] D4 is a T1 framing format that does not have bit error rate detection.

In the past, INA use was limited to special services provisioning. Some CLECs, facing the current paucity of GR-303 interface groups supported by some DLC products, have resorted to a second-best solution and used INA for regular POTS switched services. This essentially allows any number of CLECs to interconnect to the IDLC. The number of available INAs is only limited by the DS1 capacity of the transport system (e.g., 84 DS1s for a SONET OC-3 system) minus any DS1s used for GR-303 or TR-008.

3. Digital Cross-Connect System (DCS) Grooming

A DCS is an intelligent software-based network device used in the central office to electronically cross-connect DS0s between multiple DS1s using its inherent Time Slot Interchanger.[25] This is called DS0/DS1 grooming. When unbundling the large embedded base of TR-008 systems, a DCS can be used to unbundle IDLC remotes by grooming the DS1s and redirecting DS0s within specific DS1s to the ILEC or CLEC(s) (see Figure 8). Figure 9 shows one ILEC's view of DCS grooming.[26] While a DCS can support TR-008 integrated interfaces, it is incompatible with GR-303 because it does not support the Embedded Operations Channel and Time Slot Management Channel that dynamically assign time slots on a call-by-call basis and communicate with the IDLC and IDT. It thus cannot take advantage of GR-303 efficiencies.

Using a DCS may be the most efficient method of unbundling those DLCs (such as the SLC 96) that cannot support GR-303, INA, or Multiple Switch Hosting. Also, DCS grooming can be used where the TR-008 IDLC has a limited quantity of TR-008 interface groups. In addition, DCS grooming makes it unnecessary to undertake any changes at the IDLC RT, as all of the DS0 redirecting is done electronically by the DCS in the CO. It can also be used for small quantities of loops as an interim measure, until either Multiple Switch Hosting or INA is available. New facility-based service providers can use a DCS to interconnect with the embedded base of TR-008 IDLCs operating in Mode 1, eliminating the need to first convert the signal to analog or incur replacement or upgrade costs on older IDLCs.

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[25] Lucent Technologies – DACS II Release 7.0 PDS Operations and Maintenance Manual Volume 1 – Acceptance and Operations – 365-353-051 Issue 1, Section 1.2.1 --- DACSII Overview.

[26] DCS grooming as depicted in Appendix C of Bell Atlantic's report to the New York State PSC in Cases 95-C-0657, 94-C-0095, and 91-C-1174. See *Report of Bell Atlantic – New York on the feasibility of alternative means for implementing central office cross-connections*, dated November 23, 1998.

4. SIDE-DOOR GROOMING

Side-door grooming (also known as hair-pinning) is a switch-based technology that requires that the Time Slot Interchanger in the IDT of the digital switch collect and route DS0s from a DS1 port connected to the GR-303 IDLC remote to another DS1 port on the IDT for interoffice connection. See Figure 10. Side-door grooming is done in the D4 format and is only utilized for special circuits where the quantities are insufficient to warrant the cost of deploying a DCS. A major disadvantage of the side-door technique (in addition to the D-4 format) is it unnecessarily and quickly consumes ILEC IDT switch resources, since an IDT time slot is nailed up to the IDLC DS0s. Multiple Switch Hosting and INA are more efficient unbundling techniques.

Until Multiple Switch Hosting or INA is more widely available, side-door grooming may be used to unbundle a few lines since the Time Slot Interchanger at the IDT provides the same functionality as the Time Slot Interchanger at the RT. However, this is the least desirable unbundling technique.

V. CONCLUSION

GR-303 IDLC is the forward-looking DLC technology deployed in the network today because of its transmission quality, range of service capabilities, and cost efficiencies. Many CLECs have deployed Bellcore GR-303-compliant IDLC technology in their networks because it expands network capability and is cost-effective, thus benefiting consumers in two ways. But consumers will not benefit from the new technology if their decision to be served by a CLEC using unbundled ILEC loops results in their being forced off IDLC loops.

Today it is technically feasible to unbundle IDLCs. The most efficient way to provide unbundled GR-303 IDLCs is through Multiple Switch Hosting. Absent sufficient GR-303 interface groups at the IDLC RTs, Multiple Switch Hosting can also be accomplished via TR-008 and INA interface groups. Multiple Switch Hosting, as well as the other techniques described in this paper, enables IDLC unbundling and digital signal handoff to CLECs.

The UDLC and all copper facility forms of DLC unbundling are inferior. Placing a CLEC customer on a UDLC from a GR-303-capable or TR-008 IDLC is unnecessary and unacceptable because of the signal degradation and longer provisioning time for this archaic analog manual technology. TR-008 handoff, while better than a UDLC solution, is inferior to GR-303 because it does not offer variable concentration and does not utilize transport efficiently. However, where GR-303 is not available, TR-008 and INA are adequate interim unbundling solutions.

Upgrading of GR-303 IDLC systems represents a normal and necessary network modernization path because the technology is more efficient and offers better service to customers served by IDLCs. But ILECs will have an incentive to delay these network upgrades to curtail CLEC access to unbundled IDLCs. The public policy problem that regulators must grapple with is how to foster deployment of these new, efficient technologies when incumbent LECs recognize that such deployment also fosters competition.

To ensure that the advantages of these new technologies are available to CLECs and their customers, regulatory authorities should:

1. Rule that it is technologically feasible to digitally unbundle IDLCs and require CLEC access to unbundled IDLCs without manual cross connects.

2. Identify GR-303 and Multiple Switch Hosting as the forward-looking IDLC technology to be used in determining recurring and non-recurring rates for unbundled loops.

3. Ensure that CLECs receive GR-303 digital signal from GR-303 capable IDLCs whenever technologically feasible.

4. Require IDLCs to be unbundled using Multiple Switch Hosting whenever and wherever technically feasible.

5. Order TR-008 or INA unbundling until GR-303 is deployed.

6. Ensure future GR-303 requirements provide open equivalent interfaces to all carriers on an equal and non-discriminatory basis.

For further information, contact:

Chandan Choudhary
MCI WorldCom
1801 Pennsylvania Avenue
Washington, D.C. 20006
(202) 887-2667
chandan.choudhary@mci.com

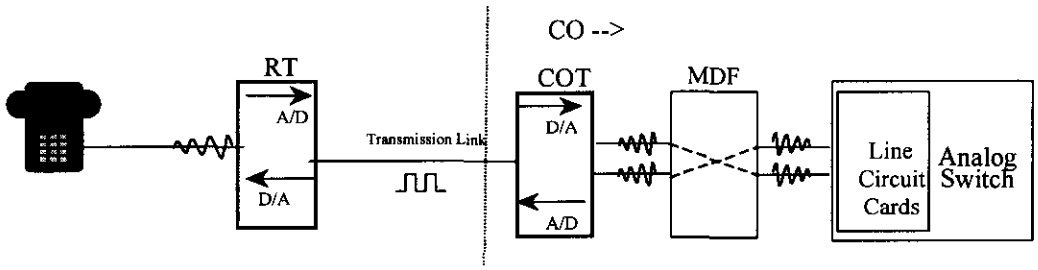


Figure 1 (a) - UDLC with an analog switch

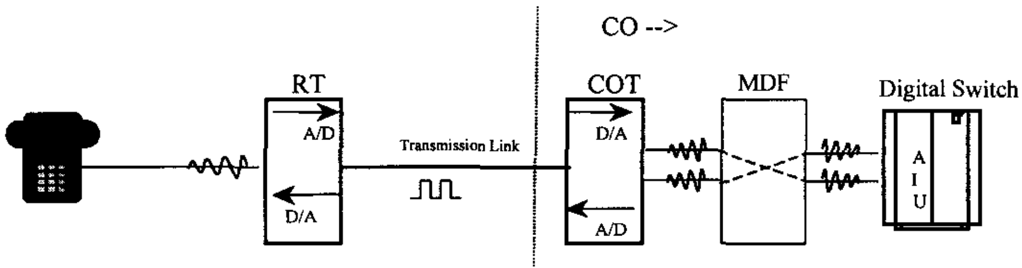


Figure 1 (b) - UDLC with a digital switch

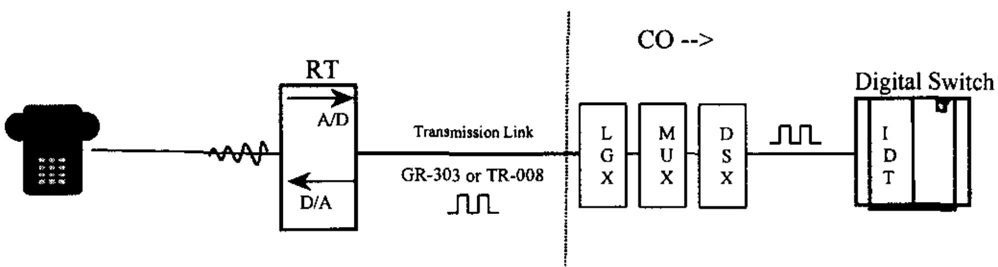


Figure 1 (c) - IDLC with a digital switch

Figure 1 UDLC / IDLC with a local switch

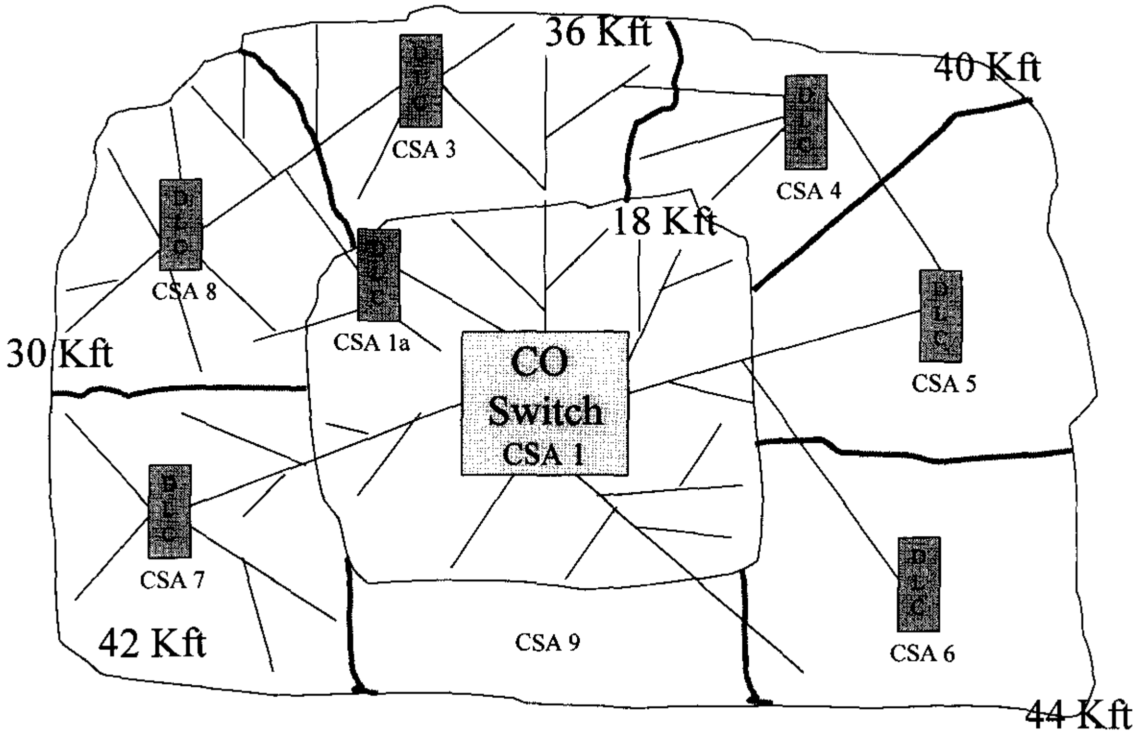
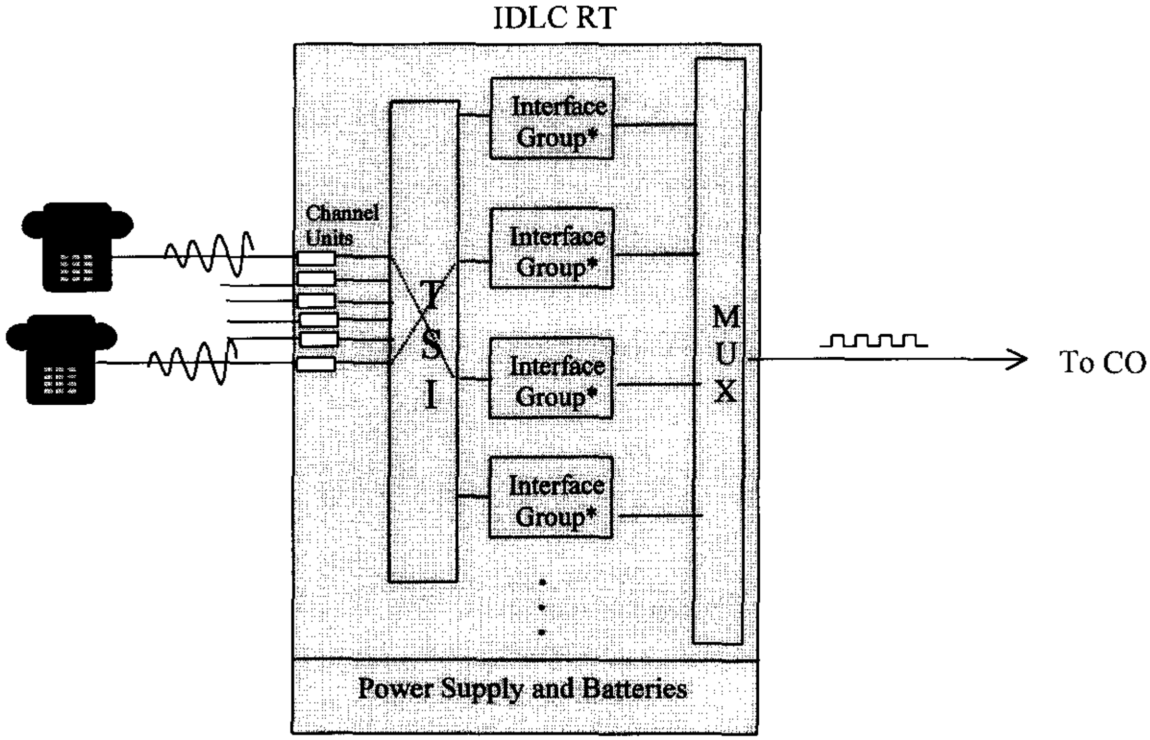


Figure 2 CSA design



* interface groups can be TR-008 or INA

Figure 3 Generic IDLC RT

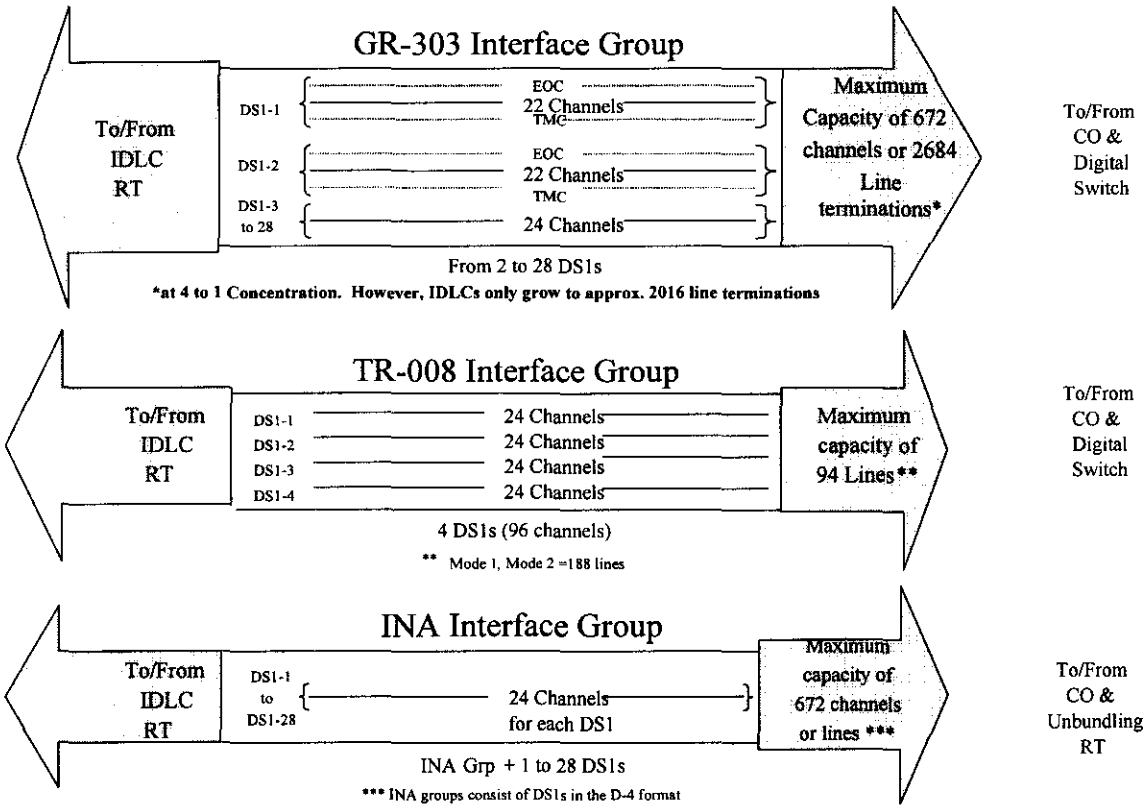


Figure 4 Interface Groups

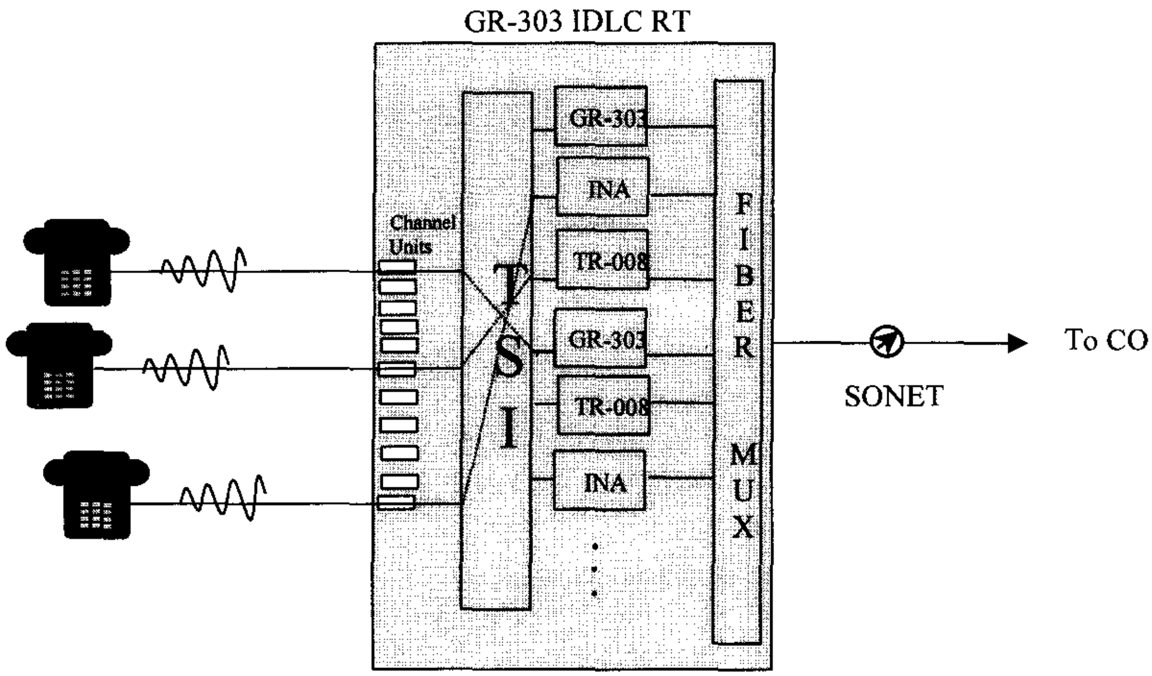
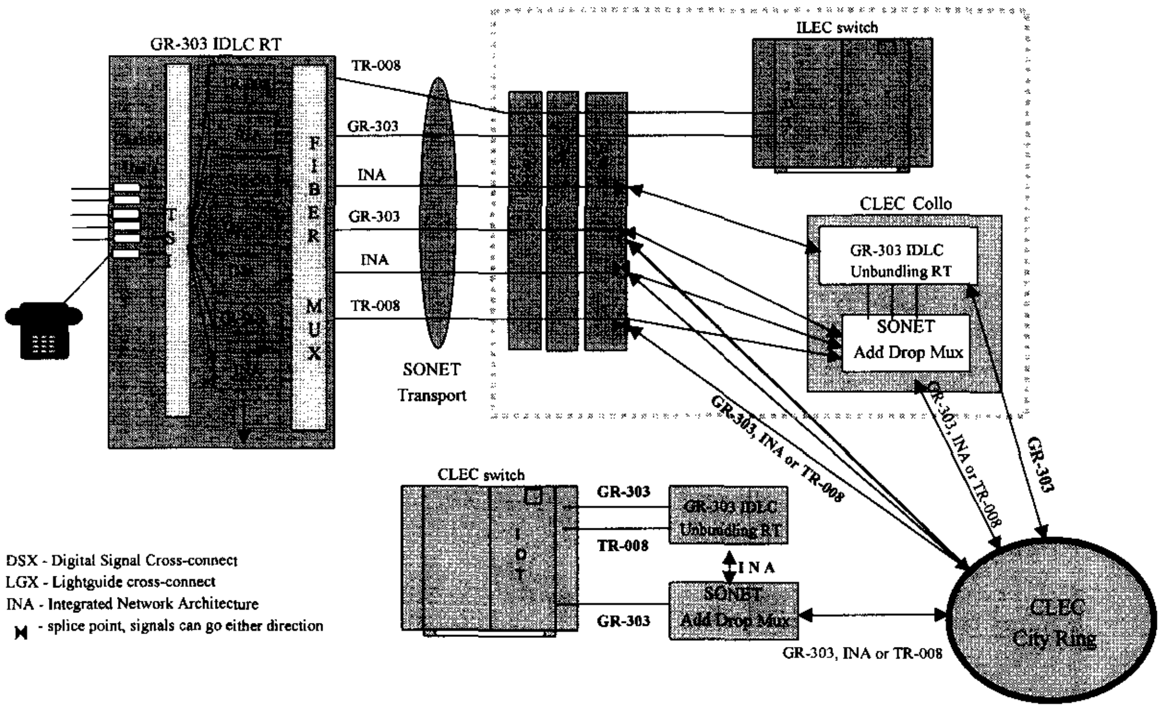
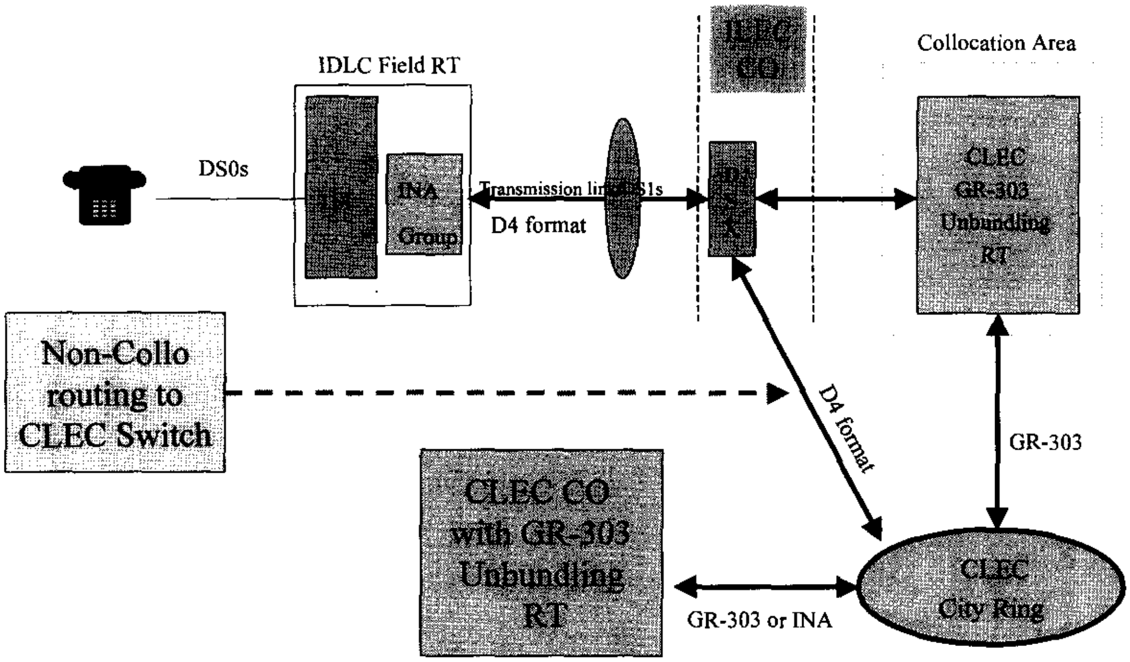


Figure 5 GR-303 IDLC RT



DSX - Digital Signal Cross-connect
LGX - Lightguide cross-connect
INA - Integrated Network Architecture
- splice point, signals can go either direction

Figure 6 Multiple Switch Hosting



(D-4 conversion via an unbundling RT)

Figure 7 INA grooming

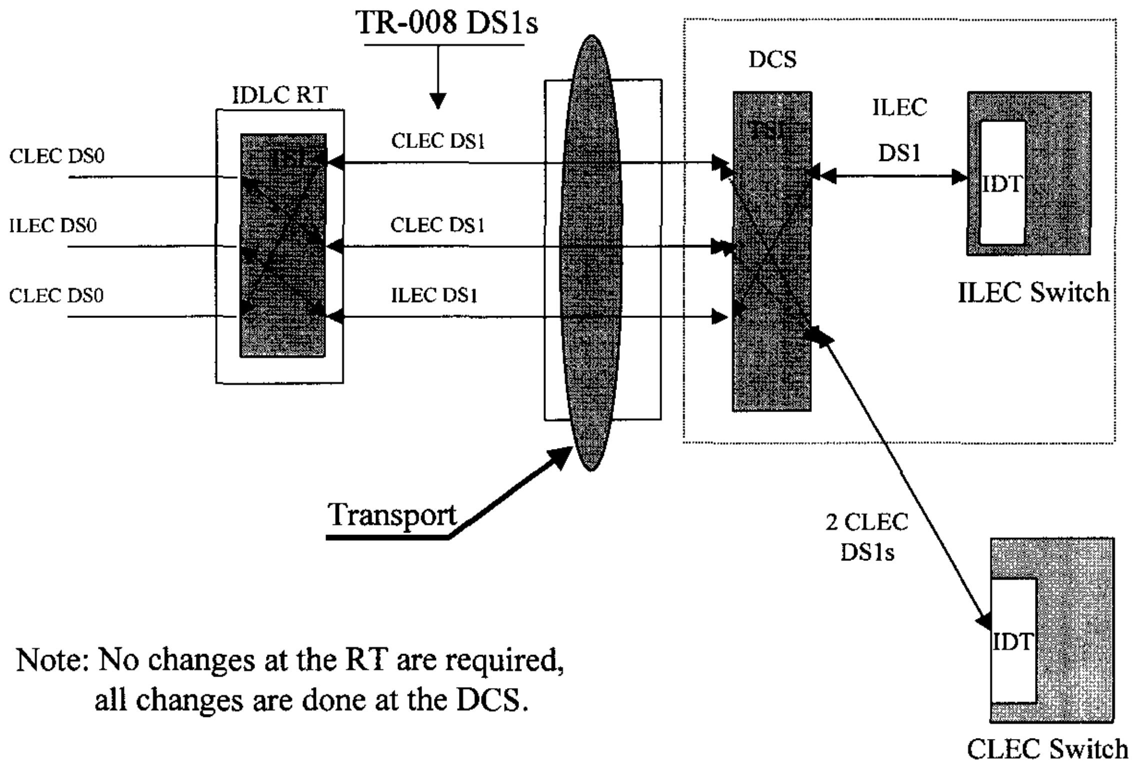


Figure 8 Digital Cross-Connect System (DCS) grooming

DS-1 Handoff

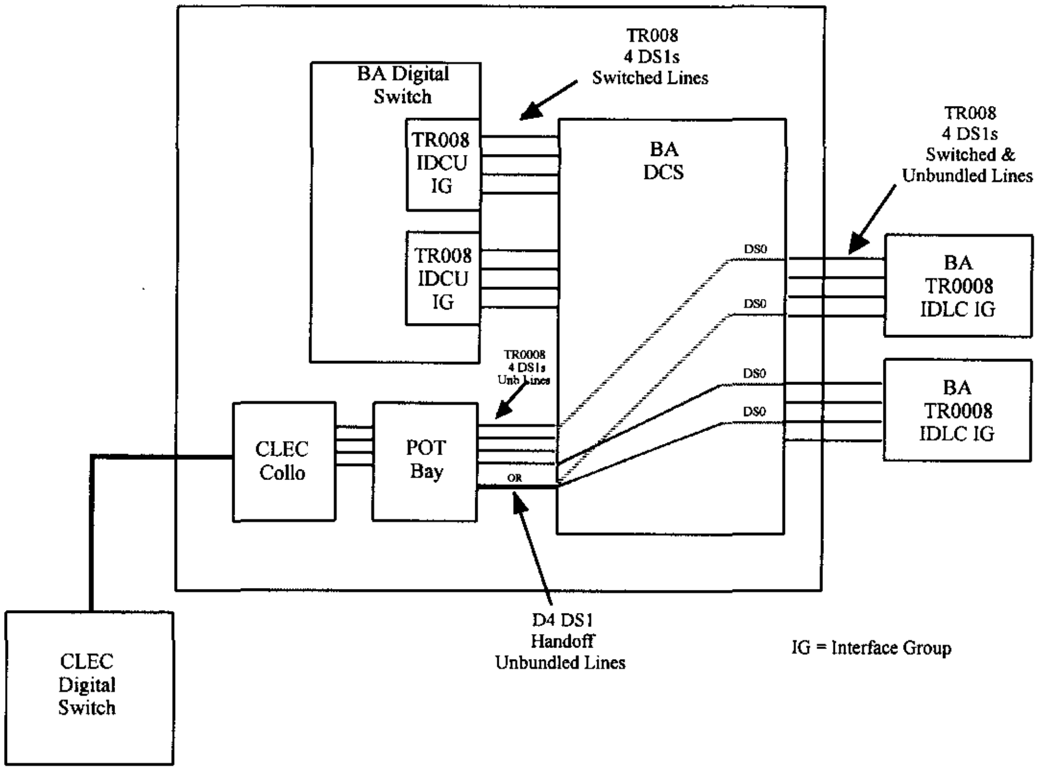


Figure 9 DCS grooming handoff to CLECs by Bell Atlantic-NY

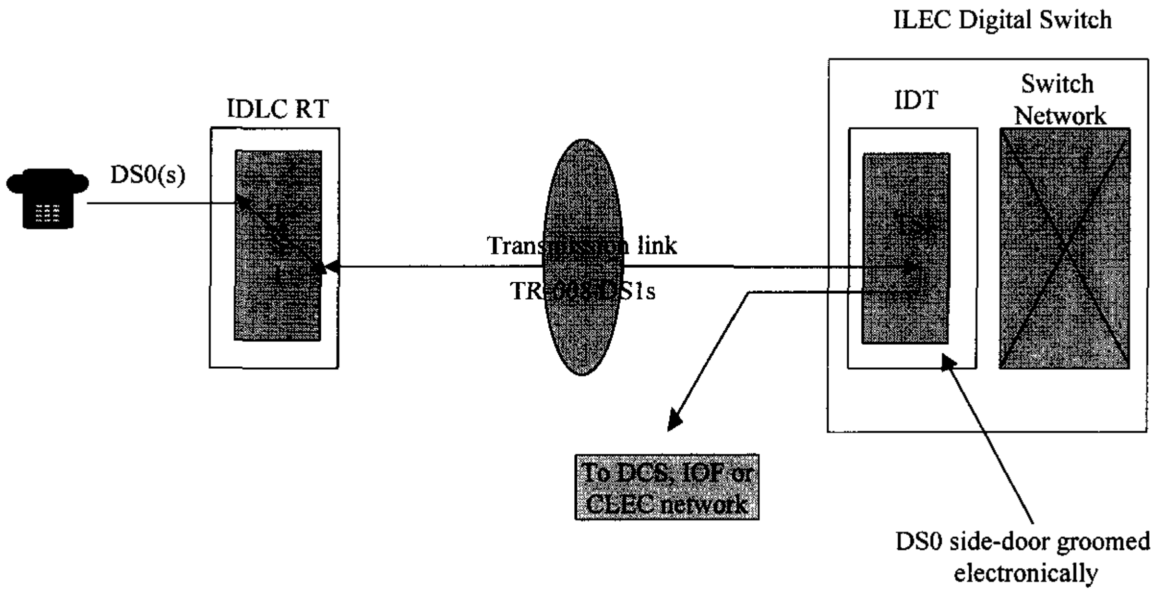


Figure 10 Side-door grooming